
Effects of positive end-expiratory pressure on intracranial pressure in patients with severe traumatic brain injury

Hongpeng Li ^a, Dongsheng Chen ^b, Zhihui Cheng ^a, Wei Qu ^a

Document Data: 2016-12-1

^aDepartment of Emergency and Critical Care Medicine, Zhoupu Hospital affiliated with Shanghai University of Medicine and Health Sciences, Shanghai 201318, PR China

^bDepartment of Critical Care Medicine, Yuncheng Central Hospital, Shanxi 044000, PR China

Corresponding author:

Dr. Hongpeng Li, No. 1500 Zhouyuan Road, Pudong District, Shanghai 201318, PR China.

E-mail: liroc119@163.com (H. Li)

Tel: +86-68135590-3352

Background: Mechanical ventilation (MV) with positive end-expiratory pressure (PEEP) is commonly applied in patients with severe traumatic brain injury (sTBI). However, the relationship between PEEP and intracranial pressure (ICP) remains unclear.

Objective: To clarify the exact relationship between levels of PEEP and ICP.

Design and Methods :

Patient Selection Criteria

This clinical study was conducted between August 2016 and August 2017 in the intensive care unit (ICU) of Zhoupu Hospital, affiliated with Shanghai University of Medicine and Health Sciences. Approval for study conduct was granted by the clinical research ethics committee (no.ZPYYLL-2016-12). Written informed consent was obtained from all participating patients or their legal guardians prior to study enrolment.

All patients diagnosed with sTBI (Glasgow Coma Scale [GCS] ≤ 8) and started on MV (Drager Infinity C500, Drager, Germany) were initially included. Exclusion criteria were: brain death; age below 18 or over 80 years; pregnancy; hemodynamic instability (eg, heart rate >120 bpm or CPP <60 mmHg); bulbous lung or pneumothorax; myocardial infarction; and refusal/inability to provide informed consent.

Design and measurement

The ICP was continuously monitored (Codman ICP Express™, Johnson,

USA) through a ventricular catheter (Codman ICP Transducer, Johnson, USA) that was associated with a closed external ventricular drain during each measurement. Both central venous and arterial catheters were inserted to measure intra-arterial MAP, CVP, and jugular bulb pressure (Pj). All patients were deeply sedated (continuous intravenous infusion of midazolam 0.05–0.20 mg/kg/h and sufentanil 0.2 µg/kg/h) to maintain the Richmond Agitation-Sedation Scale (RASS) score –5 and, thus, to remove the interference of cough and other neuronal and confounding factors on ICP. Ventilator settings remained consistent for each enrolled patient. The tidal volume was adjusted and maintained at 8 to 10 mL/kg of predicted body weight. Support pressure was maintained at 12 to 14 cmH₂O, and fraction of inspired oxygen (FiO₂) was set at 45% to 100%. An end-tidal carbon dioxide pressure (PetCO₂) device (Dräger Mainstream CO₂, SN:ASHM-0552, Dräger, German) was applied for each patient to avoid any effect of carbon dioxide pressure on ICP, and PetCO₂ was maintained at 30 to 35 mmHg during the study.

In this study, all patients were exposed to incremental PEEP levels of 0, 5, 10, and 15 cmH₂O with 100% FiO₂. Measurements were undertaken every 8 hours at the bedside on stabilized hemodynamics and ICP until MV or ICP monitoring was discontinued, and discontinued and remedied accordingly in case of: (1) CPP < 60 mmHg (norepinephrine 0.3–1.0 µg/kg/min was used); (2) ICP > 25 mmHg (PEEP was restored to 0); (3) increase in pressure plateau >35 cmH₂O (tidal volume was decreased and PetCO₂ was maintained

at 30–35 mmHg); (4) pulse oxygen saturation (SpO_2) <90% (PEEP was restored to 0); and (5) suspicion of pneumothorax (PEEP was restored to 0, and chest radiography was undertaken). An equilibration period (≥ 90 s) was entailed to ensure a normalized baseline PetCO_2 through modulation of tidal volume and respiratory rate.

The ICP, CVP, Pj, and MAP were measured three times at each level of PEEP for consecutive days after admission until MV or ICP monitoring was withdrawn. The CPP was calculated according to the following equation: $\text{CPP} = \text{MAP} - \text{ICP}$. Based on the difference between baseline ICP and CVP (intracranial central venous pressure difference, IVPD), subjects were categorized into the following three groups based on our research hypothesis and specific relationship between CVP and PEEP¹³⁻¹⁵: Group I, $\text{IVPD} \leq 3$ mmHg; Group II, $3 < \text{IVPD} \leq 6$ mmHg; and Group III, $\text{IVPD} > 6$ mmHg. Relationships between PEEP and ICP, CVP and MAP, as well as CVP and Pj were analyzed in each group, respectively.

Statistical analysis

Continuous covariates, including hemodynamic variables ICP, MAP, CVP, Pj, and CPP, were expressed as means \pm standard errors. Data were analyzed by one-way analysis of variance (ANOVA) followed by the Bonferroni post hoc test for multiple comparisons. Analysis of covariance was used to detect possible changes in continuous variables at different levels of PEEP in every group. A p -value less than 0.05 was considered as being statistically

significant.

Flow chart of study patient disposition as follow:

